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The quest for a missing key parameter: controlling the slab dip evolution in subduction systems

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In the last years several studies tried to find a correlation between the age of the oceanic lithosphere, subduction rate and the slab dip in subduction systems. The results show a poor correlation between these parameters and they propose that additional forces or factors have to be accounted for in order to improve the correlation. Knowing that dehydration of subducting lithosphere likely transports fluid into the mantle wedge, a decrease in the mantle viscosity can shape a low viscosity wedge (LVW) or a low viscosity channel (LVC) on top of the subducting slab. Using numerical models, we investigate the influence of such low viscosity wedges and channels on subduction zone structure. Slab dip changes substantially with the viscosity reduction within the LVWs and LVCs. Assuming a viscosity contrast of 0.1 with background asthenosphere, models with a LVW that extends down to 400 km depth show a steeply dipping slab, while models with an LVW that extends to much shallower depth, such as 200 km, can produce slabs that are flat, lying beneath the over-riding plate. There is a narrow range of mantle viscosities that produces flat slabs (5e+19 Pa s to 1e+20 Pa s) and the slab flattening process is enhanced by trench rollback. Slab can be decoupled from the overriding plate with a LVC if the thickness is at least a few 10s of km, the viscosity reduction is at least a factor of two and the depth extent of the LVC is several hundred km. These models have important implications for the geochemical and spatial evolution of volcanic arcs and the state of stress within the over-riding plate. The models explain the poor correlation between traditional geodynamic controls, subducting plate age and convergence rates, on slab dip.